SAFETY WITH SOLVENTS

BY H. B. HUMPHREY AND GENEVIEVE MORGIS

* * * * * * * * * **Information Circular 7757**

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Fred A. Seaton, Secretary
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Marling J. Ankeny, Director

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H. B. Humphrey[1] and Genevieve Morgis[2]

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[1] Mining engineer, Office of Assistant Director - Health and Safety, Bureau of Mines, Washington, D. C.

[2] Publications writer (Medical Sciences), Division of Health, Bureau of Mines, Washington, D. C.

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SUMMARY

The solvents used most widely in industry may be divided into groups according to their chemical and toxicological properties. These groups, with representative members, follow:

Petroleum distillates (aliphatic hydrocarbons)

Examples: Gasoline, benzine, Stoddard's specification solvents.

Alcohols, esters, ketones, ethers, and ether alcohols

Examples: Denatured alcohol (ethyl alcohol to which various denaturants may be added), methanol (methyl alcohol), ethyl acetate, amyl acetate (banana oil), acetone.

Halogentated hydrocarbons

Examples: Carbon tetrachloride, trichlorethylene, ethylene dichloride, tetrachlorethane (acetylene tetrachloride).

Aromatic hydrocarbons

Examples: Benzene (benzol), toluene (toluol), xylene (xylol).

Carbon disulfide trisodium phosphate

Many of the solvents marketed and used today are not single substances but mixtures of various chemicals, frequently under trade names. The approximate composition of the solvent must be determined so that safe control measures can be applied and the users instructed in precautions to be observed. Ventilation must be provided to keep the vapor concentration below the lower explosive limit and also below the recognized safe limit for daily toxic exposure. Solvents having the least toxic qualities should be used when they will satisfactorily replace more toxic solvents. Special protective equipment should be used where other measures will not eliminate risks of contact or breathing. All use of solvents should be with full knowledge of the hazards involved.

INTRODUCTION

Because new tools, materials, finishes, and methods have been developed in the mineral industries, as in other industries, the need has grown for more effective solvents to clean and maintain the equipment. The variety and the quantity of solvents in use have increased tremendously. In recent years the experience with solvents has demonstrated the hazards inherent in their use, and investigation has shown ways in which the dangers may be controlled or eliminated. Recognition of these facts has created a demand in various industries for information and education on the hazards and safeguards relating to solvents that are used or available. Considerable material has been compiled and published on these subjects, part of which is listed in the bibliography included in this circular (1-14).[3] Depending on the intended field of use, these publications range from short articles or shop manuals to voluminous technical tomes for research and reference purposes.

Field engineers in Bureau of Mines health and safety activities indicated a need for a published reference that would help in their work of safety education and training at mines and plants. This circular has been prepared to serve that purpose. Most of the information has been assembled from the references shown in the bibliography.

USES OF SOLVENTS

The word "solvent" is applicable to any substance that will dissolve another. In industry, a primary specialized function of solvents is cleaning. The substance to be dissolved, for the most part, is some form of oil. Because oil does not dry, its presence on a surface provides a sticky place to trap solids, such as dust, carbon, metal particles, or fibers. Solvents and solvent mixtures have been widely applied, both in industry and in the home.

TYPES OF SOLVENTS

Many of the common industrial solvents may be classed as either petroleum (aliphatic), aromatic (coal tar), or chlorinated hydrocarbons, as well as a variety of other chemical compounds and mixtures.

Petroleum Solvents

Some hydrocarbon mixtures that are derived from petroleum and used as solvents are gasoline, kerosine, and Stoddard solvent. All are flammable liquids; however, Stoddard solvent is less hazardous than the more flammable hydrocarbon mixtures such as gasoline and kerosine. All these materials have various degrees of flammability and are explosive when the percentage of solvent exceeds about 1 percent, by volume, in air. Gasoline and low-flash naphtha are usually so highly flammable that it is well to exclude their use as cleaning agents.

Stoddard solvent differs from other petroleum solvents in that it has a narrow distillation range; the low-boiling constituents that produce flammable mixtures with air at ordinary temperatures and the high-boiling fractions that evaporate slowly are removed from the solvent in refining. The flashpoint of Stoddard solvent is about that of kerosine, and the flammability range at 212° F. is between 0.74 and 5.60 percent by volume. Stoddard solvent has other characteristics that surpass those of kerosine as a cleaning agent; for example, Stoddard solvent has a higher evaporation rate in open air than kerosine and therefore dries more quickly.

Aromatic Solvents

Some commonly used aromatic solvents are benzene, toluene, and xylene. They have greater solvency than most other compounds and sometimes are known commercially as benzol, toluol, and xylol. Their vapors are much more toxic than petroleum-solvent vapors, and their degreasing action on the skin is more rapid and severe. Owing to the much greater toxicity of benzene, its use should be limited as much as possible or eliminated (13).

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[3] Underlined numbers in parentheses refer to items in the bibliography at the end of this report.

Chlorinated Hydrocarbons

Chlorinated hydrocarbons, such as carbon tetrachloride, trichloroethylene, and tetrachloroethylene (perchloroethylene), are effective cleaning agents for some uses. They are nonflammable, but the vapors are toxic in relatively low concentrations, and they must be used only under controlled conditions that will insure adequate ventilation. Because of the very high toxicity of carbon tetrachloride, it is being rapidly replaced by the less toxic chlorinated solvents that are usually equally effective.

Alcohols and Acetates

The alcohols are usually highly flammable and have a low order of toxicity, except for methyl alcohol, which is very toxic. Optic nerve damage is of greatest concern. Acetates are frequently used as solvents for cellulose acetate coatings such as lacquers. These solvents are highly flammable and may irritate the mucous membranes, such as the eyes and respiratory tract. Carbon disulfide is highly toxic and may affect the nervous system; it is explosive in concentrations of 1 to 50 percent in air (13).

Inorganic Chemical Compounds

Trisodium phosphate, sodium sesquicarbonate, and a variety of other compounds under many trade names are in the inorganic chemical compound group. Many of these compounds are suitable for washing in vats or in steam-cleaning equipment.

Trisodium phosphate has been used extensively for several years for cleaning machine parts, with the exception of aluminum, which it may attack and discolor. Trisodium phosphate is nonflammable, has no objectionable odor, and may be used in hot- or cold-water solutions, although the cleaning action may be accelerated if the solution is heated. It is customary to leave the machine parts in trisodium phosphate baths for a period of time best determined by experience, in some instances overnight. The parts should be washed or rinsed with water after they are removed from the vats.

Steam

Several steam-cleaning machines are available for use in surface shops, and permissible machines are available for operation on 250 or 500 volts direct current and 220 or 440 volts alternating current in coal mines. The process of cleaning with steam when compounds are added is rapid and very effective.

Solvent Mixtures

Many commercial solvent mixtures of chlorinated and petroleum solvents have been put on the market, partly through the demand for a less toxic substitute for the highly toxic carbon tetrachloride. Although some claims are made that these mixtures are of low toxicity or nontoxic, they contain one of several chlorinated solvents and have a degree of toxicity depending upon the percentage and kind of chlorinated solvent used in the mixture. The chlorinated-solvent fraction is frequently more volatile than the petroleum-solvent fraction, and therefore such mixtures are not stable with use, and both fire and toxic hazards may exist through evaporation (13).

HAZARDS FROM SOLVENTS

Several characteristics must be considered in using any solvent. These include toxicity, potential skin irritation, degree of flammability, flashpoint, evaporation rate, and ventilation requirements, as well as economic values.

FLAMMABLE SOLVENTS

The vapors of most common organic solvents are very flammable, although those of chlorinated hydrocarbons are somewhat less so. Underwriters' Laboratories have rated organic solvents in respect to flammability by a scale on which carbon tetrachloride is zero and carbon disulfide 100. Interstate Commerce Commission regulations define flammable solvents with flashpoints below 80° F. as belonging to group A flammable materials. Group B includes those solvents with flashpoints between 80° and 110° F. and group C solvents with flashpoints above 110° F.

Three properties having to do with flammability are generally recognized. The first of these is the flashpoint, by which is meant "the lowest temperature at which enough vapors are given off to form a flammable mixture of vapors and air immediately above the liquid surface." This implies the presence of a spark or open flame. The flashpoints of various solvents differ widely. The barometric pressure affects them just as it does the boiling point. It is essential to realize that flashpoint varies with pressure and that it is quite possible to have an ignitable or explosive mixture far below the stated flashpoint value at pressures less than 760 mm. Hg.

The firepoint of a solvent has been defined as "the lowest temperature at which a liquid will give off enough vapor to continue to burn when once ignited." The firepoint is usually a little higher than the flashpoint.

The temperature at which a mixture of a solvent vapor and air will ignite without the aid of a spark or flame is known as the autoignition point of the solvent. This tendency of certain liquids to catch fire spontaneously can result in serious fires or explosions if proper precautions are not taken. Such liquids give off heat when they vaporize; and, if they are in a confined space where the heat builds up faster than it can be dissipated, spontaneous combustion will occur (5).

For practical purposes flammable solvent vapors should not exceed 25 percent of the lower explosive limit unless an approved flammable vapor alarm is in operation; then the concentration should not go over 50 percent of the lower limit.

Safety Measures

A sizable literature has grown up on the subject of safe handling of solvents. The Safety Research Institute (New York) and the National Safety Council (Chicago) publish material to give better understanding of the subject by all who make and use dangerously flammable materials. In addition to other articles listed in the bibliography, reference should be made to the Chemical Safety Data Sheets prepared by the Manufacturing Chemists' Association (Washington, D. C.), which give complete hazard and safety data for commonly used solvents. The National Fire Protection Association (Boston, Mass.) has published recommendations governing handling of solvents.

The Bureau of Explosives of the United States Department of Commerce (30 Vesey Street, New York) issues periodic bulletins governing the labels and other transportation regulations for shipping flammable and explosive materials.

Suggested rules relating to safe handling of flammable solvents include (see figs. 1 and 2) (13):

> Solvents should be received in containers that are not easily broken, such as metal. These containers should be labeled with the name of the material and a brief statement of necessary precautions regarding flammability, toxicity of vapors, or possible unfavorable reaction with the skin. When solvents are taken from a large container and placed in small containers the name of the material as well as warning labels should be put on the small containers.
>
> Solvents should be stored in an approved storage space or building that is cool, ventilated, and constructed from noncombustible material. Usually, only one drum of a flammable solvent should be permitted at any shipping location, unless an approved storage space in each location is provided. All flammable solvents should be kept in safety cans equipped with flash arrestor screens. The cans themselves should be approved by Underwriter's Laboratories.
>
> Barrels containing flammable solvents should be provided with safety bungs and safety spigots. These safety bungs and safety spigots should have an Underwriter's approval to be certain they will not transmit a flame and permit an explosion of the vapors within the barrel. If barrels are in a vertical position, the contents should not be forced out of the barrel by pressurizing the barrel above the liquid with compressed air. An Underwriter's Laboratories approved pump should be used for dispensing liquid from barrels in a vertical position.
>
> Forced ventilation is usually necessary for proper ventilation of solvent storage areas and provision must be made for air to enter the room as rapidly as the forced ventilation system is attempting to remove it.
>
> Where flammable solvent vapors are being used, adequate fire extinguishing equipment should be on hand. This equipment should be automatic whenever practical.

Some safety requirements for certain flammable solvents follow:

There is a Federal specification for Stoddard solvent, known as Commercial Standard CS3-40, the scope of which covers physical and chemical properties, methods of testing, and certification of the grade of petroleum distillate. Some of the important requirements in Commercial Standard CS3-40 affecting safety in the use of the solvent cover the flashpoint and distillation range. The flashpoint shall be not lower than 100° F., and the distillation range shall conform to the following:

50-percent distillation at 350° F.
90-percent distillation at 375° F.
Endpoint (maximum distillation), 410° F.

The various producers of Stoddard solvent have been able to market a product well within these requirements.

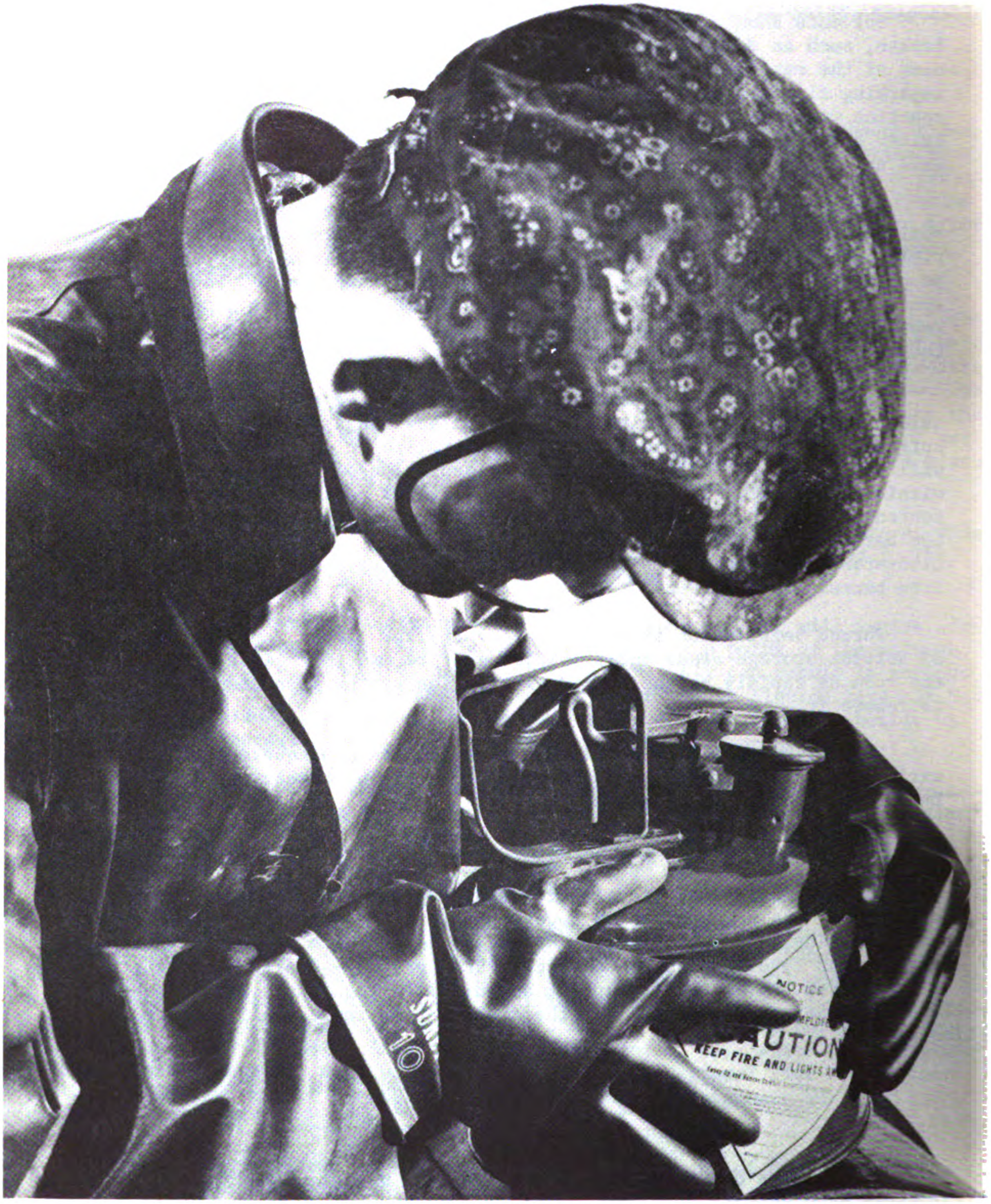
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Figure 1. - Using label to identify flammable solvent.

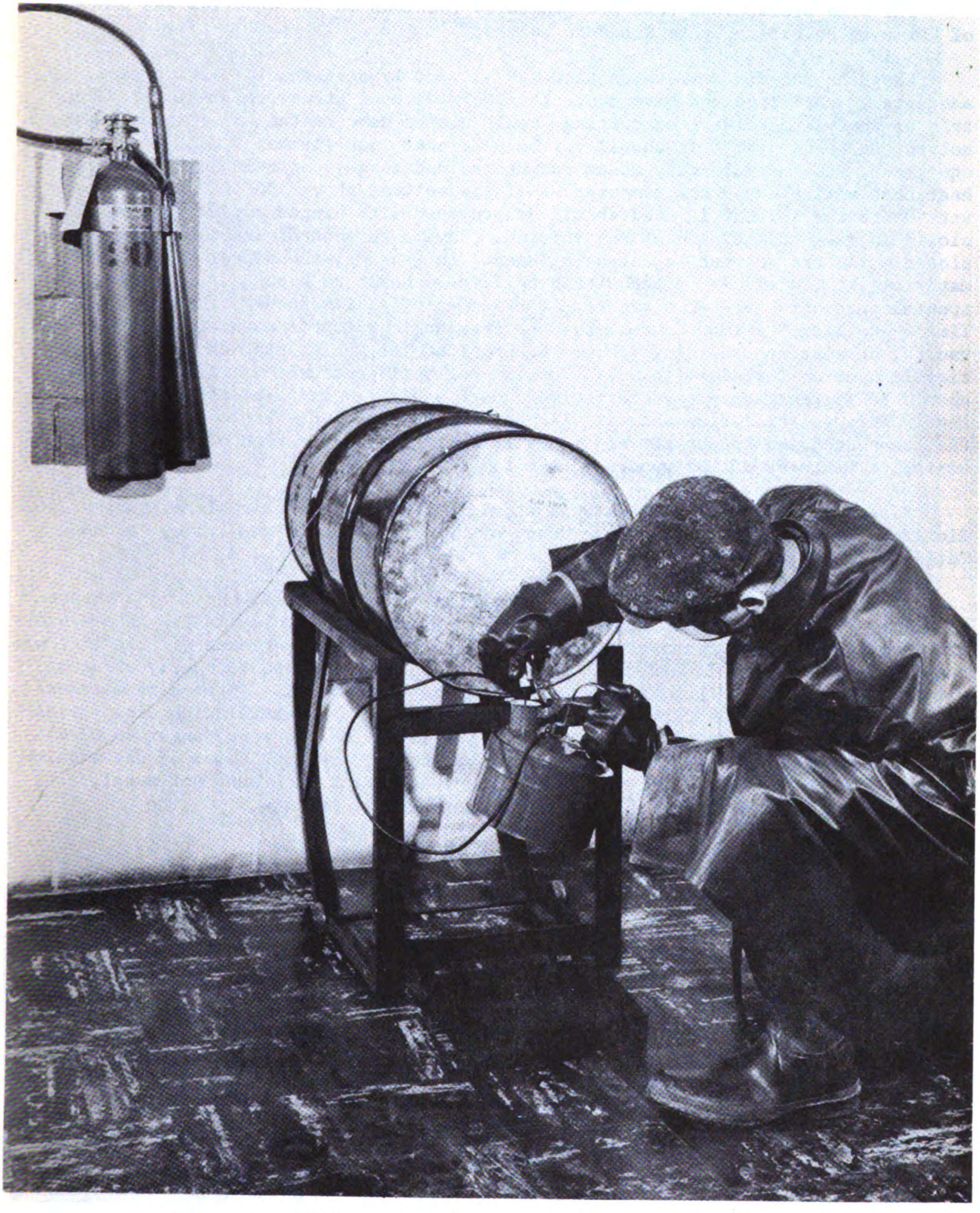

Figure 2. - Filling approved container with flammable solvent.

The same precautions that are generally recommended for handling and storage of kerosine should apply to Stoddard solvent.

Shops or buildings in which Stoddard solvent is used should be fireproof and adequately ventilated and have concrete floors without cracks or crevices. Electric or acetylene welding or cutting should not be done in the building while the solvent is being used. It should not be used near open flames or near heating equipment, such as furnaces, steam radiators, and forges, or near any sources of heat that will elevate the temperature of the solvent above 100° F. Containers or vats where the solvent is used should be equipped with hinged covers that can be closed in case of ignition of the solvent. Covers for containers should be kept closed while the solvent is not being used. In general, the amount of hazardous materials at individual points within buildings should be kept at a minimum unless special protective measures are taken. Flammable liquids should, in general, be limited to 1 or 2 gallons and kept in safety cans. Suitable cabinets, vented vaults, or separate buildings should be provided for the storage of larger quantities in cans or barrels (fig. 3). Portions of buildings used for such storage should be segregated by fire-resistive floors and walls and protection for openings. When volatile flammable liquids are stored, handled, or used, it is essential that occupied spaces be ventilated to prevent the formation of flammable or explosive mixtures of the vapors with air.

Fires involving Stoddard solvent should be extinguished with foam, carbon dioxide, dry chemicals, sand, rock dust, or, if in an unconfined space, carbon tetrachloride-type fire extinguishers.

An example of the consequences of improper handling of solvents was a disaster resulting from the ignition and explosion of carbon disulfide cylinders in a vehicular tunnel. Several factors combined to produce a severe accident (1) the extreme sensitivity of carbon disulfide to heat (its vapor ignites spontaneously at about 212° F.; (2) the fact that it gives off poisonous fumes; and (3) the circumstances of the explosion, which occurred in a partly enclosed area where quick dissipation of the fumes was impossible. Carbon disulfide is one of the most dangerous of all commercial solvents, and its storage, transportation, and conditions of use should be strictly supervised. For example, it should not be used around hot metal, electric lamps, or in any location where sparks are likely to occur.

TOXIC SOLVENTS

The index of the toxic qualities of solvents is their maximum average atmospheric concentration to which workers may be exposed for an 8-hour working day without injury to health. This is usually expressed as so many parts of vapor per million parts (p.p.m.) of air. The values are based on the best available information from industrial experience and from experimental studies. They are not fixed values but are reviewed annually by the Committee on Threshold Limits of the American Conference of Governmental Industrial Hygienists. The values established as of April 1955 are given in table 2 in the appendix. Later revisions may be found in current periodicals, particularly the Archives of Industrial Health published by the American Medical Association. Threshold limits should be used as guides in the control of health hazards and should not be regarded as exact limits between safe and unsafe concentrations.

> The Chemical Safety Data Sheets issued by the Manufacturing Chemists' Association (Washington, D. C.) give complete details as to the type of hazards encountered with all the most widely used solvents, including oral intake. However, in speaking of the toxic hazards

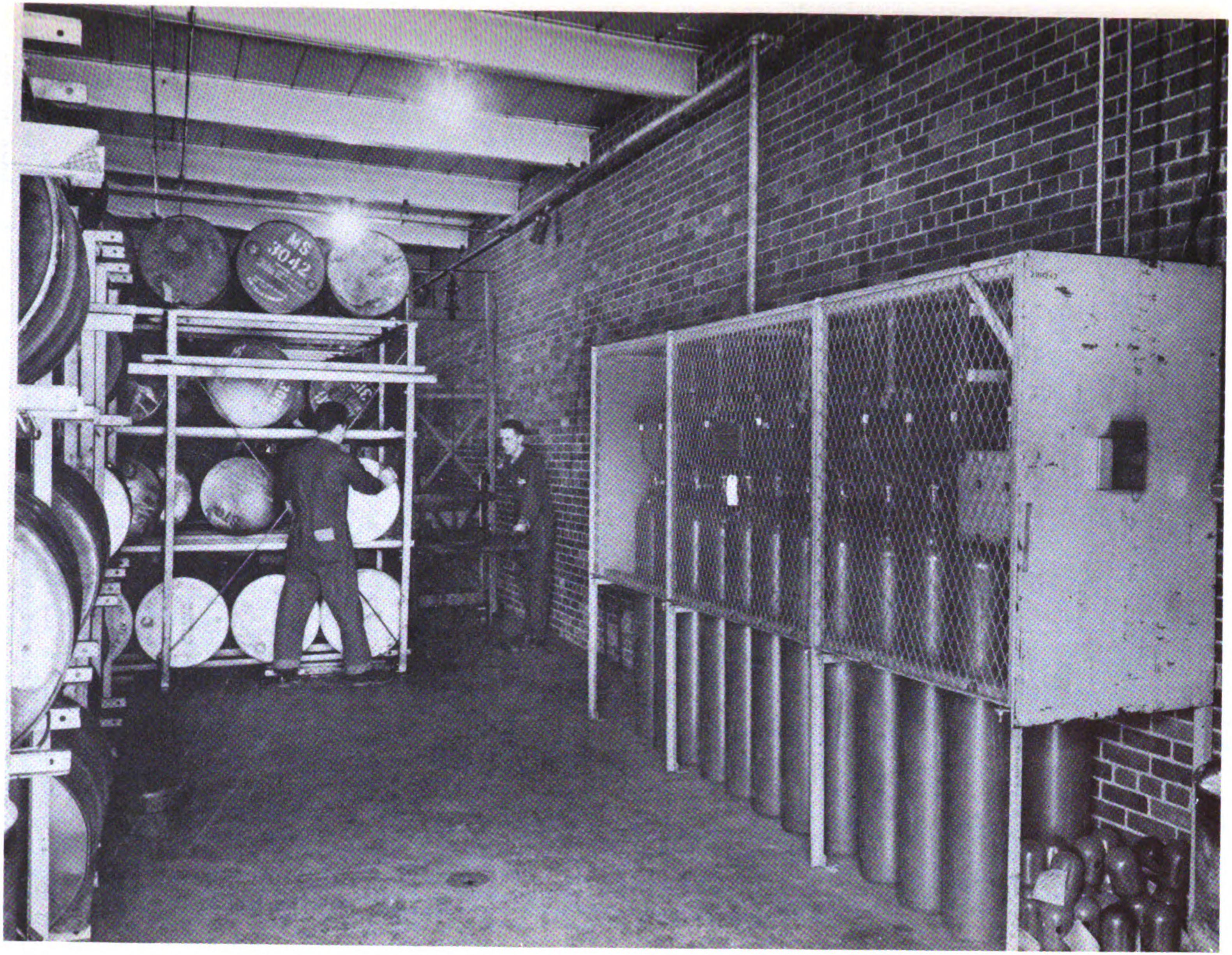

Figure 3. - Permanent fire-fighting equipment.

of a solvent, the vapor concentration to which workers are exposed is usually implied, rather than accidents involving swallowing of the liquid. Poisoning caused by inhalation of solvent vapors or external bodily contact may be either acute, subacute, or chronic. An indication of the major symptoms encountered in these states is given below: (5)

Acute poisoning may cause:

- Stiff leg muscles
- Headache
- Dizziness
- Forehead pressure
- Irritation of mucous membranes
- Nausea
- Narcosis
- Hysteria
- Blindness (methanol)
- Circulatory failure (trichloroethylene)
- Respiratory failure (benzene)
- Death

Subacute poisoning may cause:

- Fatigue
- Headache
- Dizziness
- Eye inflammation
- Visual disturbances
- Nausea
- Jaundice
- Liver dysfunction
- Nerve paralysis
- Heart fibrillation

Chronic poisoning may cause:

Anemia
Blood cell damage (benzene)
Nerve damage
Dermatitis) benzene
Skin dryness) trichloroethylene

Safety Measures

One of the most effective protective measures against both flammability and toxicity is the proper education of personnel. This point is often overlooked and it cannot be emphasized too greatly. Employees should be aware of the insidious nature of toxic fumes and of the symptoms resulting from over-exposure. No mechanical equipment can substitute for such safety education, for no matter how quickly a fire is extinguished or a worker resuscitated, it would have been better if the accident had not occurred. Employee education can be achieved by periodic lecture or instruction groups, by safety posters, and by careful daily checking of plant conditions by department supervisors (5):

Enough general ventilation should always be provided to prevent the solvent vapors from exceeding the maximum allowable concentration for safe breathing. Occasionally it becomes preferable economically to supply persons with respiratory equipment where only very short exposure is expected or ventilation would not be practical. Self-contained breathing equipment, air-line respirators, or hose masks should be provided workers if there is a possibility of oxygen deficiency, as may exist in storage tanks or degreasers that formerly contained solvents (figs. 4 and 5). Respirators are designed to give adequate protection for certain purposes. Respirators are designed to give adequate protection for certain purposes. Dust or fume respirators are seldom adequate for solvent vapors or vice versa. Solvent-vapor respirators require treated charcoal cartridges for absorption of the vapors, respiratory equipment that is self-contained, or equipment that has a hose attachment to supply only safe air from an uncontaminated source. All respiratory equipment and replacement parts should be Bureau of Mines-approved; they can be recognized by the approval label (13).

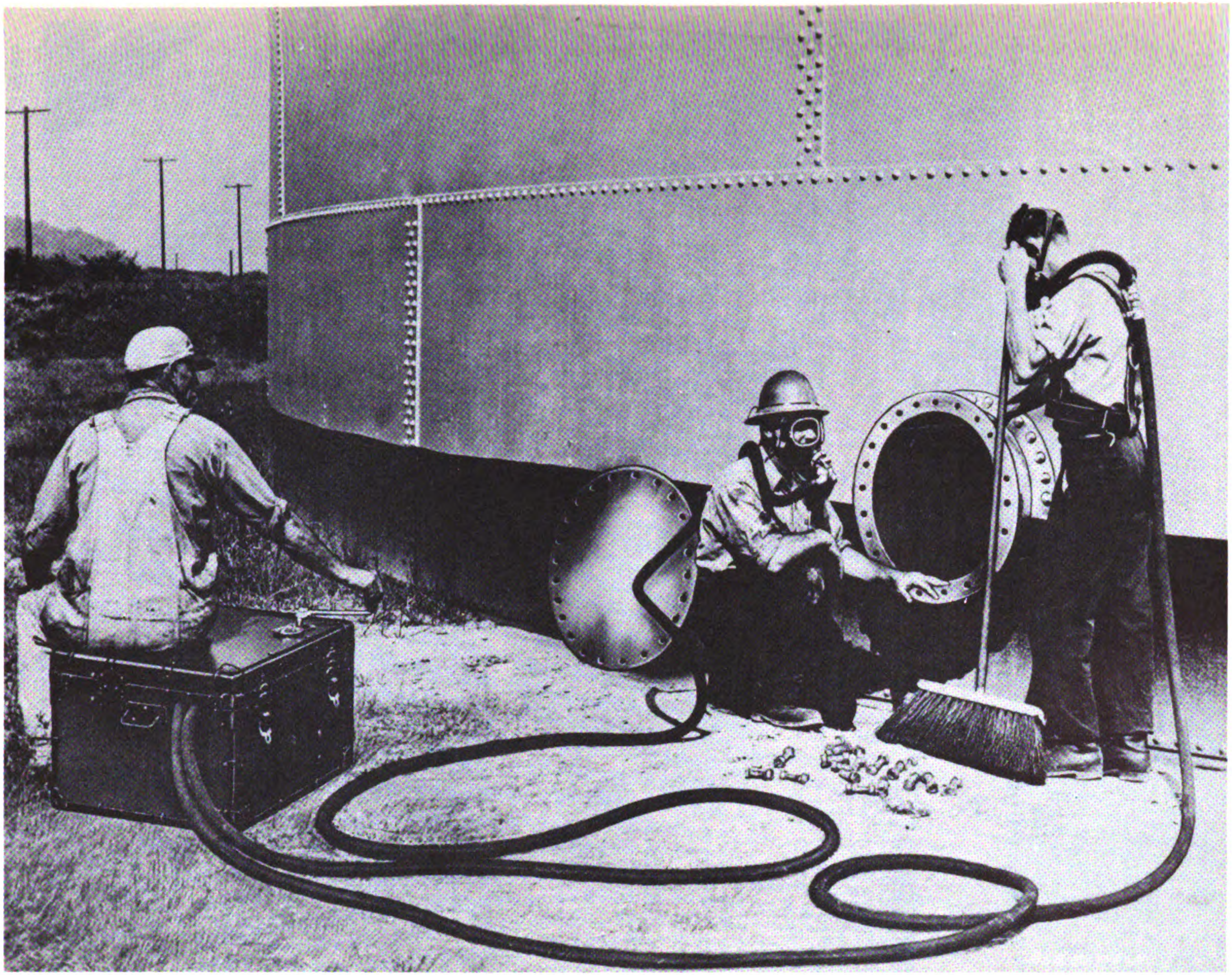

Figure 4. - Use of air hose when entering storage tank.

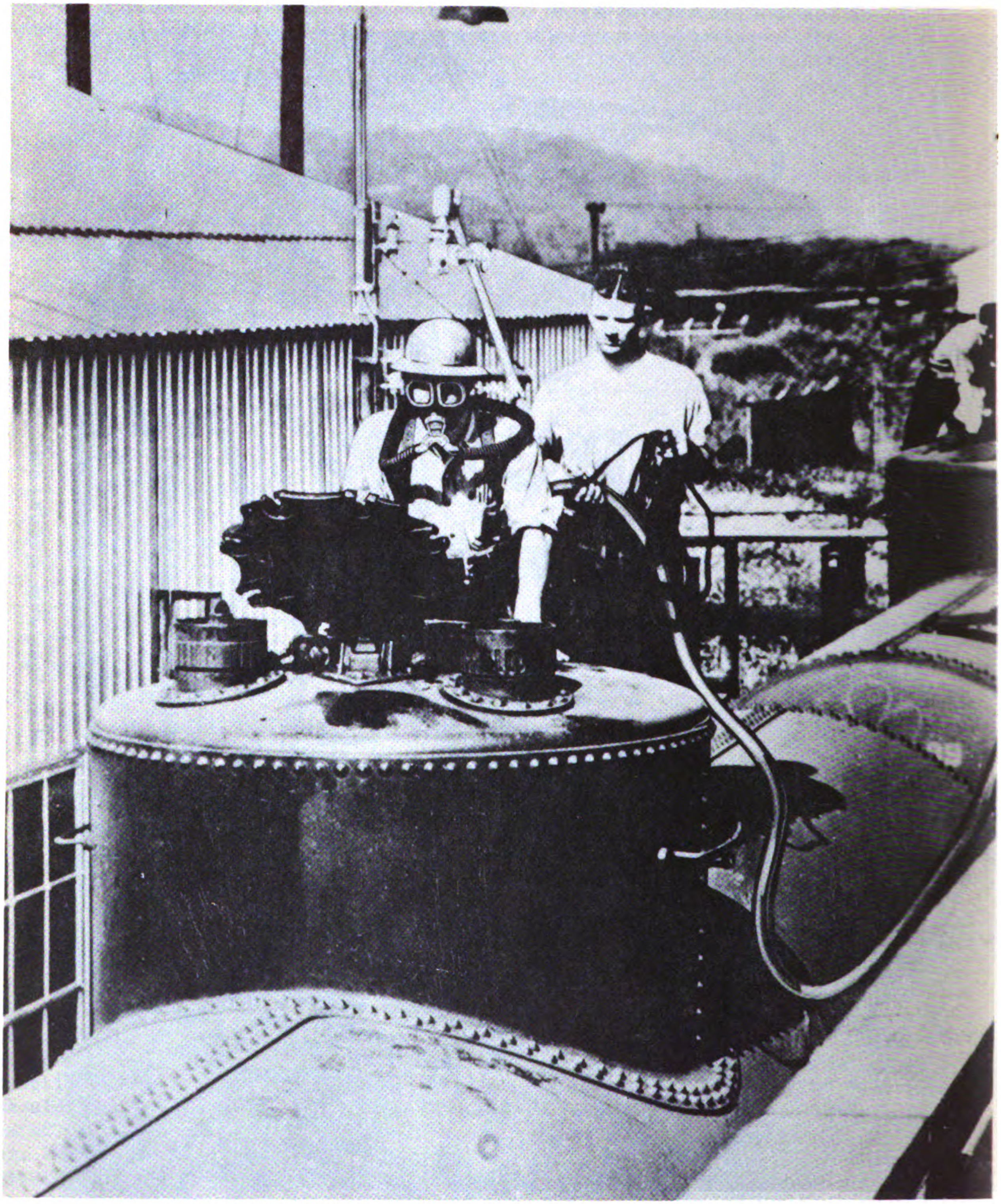

Figure 5. - Use of air hose when entering tank car.

Protective clothing prevents solvents from coming in contact with the skin or a worker's regular clothing and producing severe skin irritation or being absorbed through the skin in toxic concentrations. The cloth or material should not acquire a static charge during use.

Hand creams are usually little protection against the solvents with the higher solvency powers, such as chlorinated and aromatic solvents, but some give reasonable protection against mild aqueous solutions and petroleum solvents.

Solvents should not be used for removing dirt or grease from the hands or other portions of the skin. Nonirritating, powdered hand soaps or waterless hand creams are commercially available.

Some safety requirements for some toxic solvents are:

For persons susceptible to petroleum, the Public Health Service recommends that the hands be cleaned immediately following the use of the solvent or that rubber gloves be used to prevent contact with the skin. For most persons, however, Stoddard solvent is not bothersome when used intermittently, although it should be recognized that such solvents remove natural oils from the skin, causing it to become dry and possibly promoting a tendency to crack.

Methyl alcohol (methanol, wood alcohol) is very toxic, and vapor concentration should not exceed 200 parts per million. Optic nerve damage is possible, and in extreme cases blindness may result. Care should be taken to prevent skin contact and breathing of vapors or mists from solutions containing phenols or cresols, which are part of many compounded solvents for removing carbon deposits from metals.

Besides their inhalation hazards, direct contact with benzene, trichloroethylene, and other solvents of similar nature should be avoided, as prolonged exposure will cause dermatitis. Protective creams and lotions that give best results are reported to be those containing lanolin, which tends to supply the oils removed from the skin by these solvents. Wearing gloves and prompt washing after exposure are advised.

Carbon tetrachloride is still used for cleaning motors and motor parts, but even here a satisfactory substitute has been found in methyl chloroform. Present experience indicates that this solvent can be used safely in higher concentrations than carbon tetrachloride (CCl_4). It has the same properties, except for its reaction on aluminum, but is used in contact with that metal with certain additives. The Manufacturing Chemists Association states that carbon tetrachloride can be handled safely but users should observe adequate labeling, storage, ventilating, and other controls and should wear personal protective equipment. Breathing or prolonged skin contact with CCl_4 or its vapors should be prevented. Even a few ounces in an open container can be dangerous. Another danger arises from contact of liquid or vapors with open flame, resulting in the production of still more deadly phosgene gas. Carbon tetrachloride fire extinguishers should be used only where ventilation will sweep decomposition products away from the user or other persons who might be exposed.

Tetrachloroethane is toxic by inhalation, by prolonged and repeated contact with skin or mucous membranes, or by oral intake. Although toxic, it may be handled safely if suitable precautions are constantly observed. Prolonged or repeated exposures to the product in any form are hazardous. The recognized maximum allowable concentration is 5 parts per million in air for an 8-hour working day. Tetrachloroethane is currently considered the most toxic of the chlorinated-hydrocarbon solvents in industrial use. Personal protective equipment is not a substitute for good, safe working conditions, adequate ventilation, and intelligent conduct on the part of persons working with tetrachloroethane or in the area of its use. Protective equipment includes, safety goggles or face shields, approved respiratory protection, head, foot, and hand protection, and solvent-proof aprons or clothing. Processing should not be near open flame or other sources of high temperature, as the vapors may be decomposed to toxic and corrosive substances, such as phosgene. Tetrachloroethane should always be used in closed equipment, and adequate ventilation must be provided.

Methyl chloride is toxic by inhalation. It has narcotic and anaesthetic properties about one-fourth as active as chloroform, and repeated exposures are dangerous. Serious return of symptoms may occur after apparent recovery from mild exposures. Instruction and supervision will control the hazards. Physical examinations should include emphasis on possible anemia or nervous trouble. Care should be exercised to see that concentrations do not exceed 100 parts per million during an 8-hour day.

Triosodium phosphate solutions apparently are not injurious to the skin when used intermittently in concentration required for ordinary cleaning, namely, 8 ounces or less of trisodium phosphate to 1 gallon of water. Where difficult cleaning is encountered, a stronger solution may be required.

Many of the foregoing data are from the Chemical Safety Data Sheets published by the Manufacturing Chemists' Association, Inc. When the ingredients of solvents are known, data sheets may be obtained giving complete information on the hazards and protective measures for each ingredient. The address of the association is 1625 I Street, NW., Washington 5, D. C.

APPENDIX

Properties of flammable liquids, gases and solids[4]

Name	Synonyms	Flashpoint, °F.		Explosive limits % by vol. in air		Autoignition temp. °F.	Susceptibility to spontaneous heating	Specific gravity (water = 1.00)	Vapor density (air = 1.00)
		Closed cup	Open cup	Lower	Upper				
Acetal	Acetaldehydediethyl-acetal	-5	-	1.65	-	446	-	0.821	4.08
Acetaldehyde	-	-17	-	4.0	57.0	365	No	.783	1.52
Acetanilide	Antifebrin	345	345	-	-	-	-	1.21	4.65
Acetic acid (glacial) ...	-	104	110	4.0	-	1,050	No	1.05	2.07
Acetic anhydride	-	121	130	-	-	752	No	1.08	3.52
Acetone	Dimethyl ketone	0	15	2.15	13.0	1,118	No	.792	2.00
Acetophenone	Phenyl methyl ketone	221	-	-	-	-	No	1.03	4.14
p-Acetotoluide	Tolylacetamide	335	355	-	-	-	-	1.212	5.14
Acetyl chloride	-	40	-	-	-	-	No	1.105	2.70
Acetylene	-	Gas	-	2.5	80	635	No	-	.91
Acetylene tetrabromide ..	Tetrabromoethane	Nonflammable		-	-	-	No	2.97	-
Acetylene tetrachloride .	Tetrachloroethane	do.		-	-	-	No	1.58	5.73
Acrylonitrile	-	-	32	3.05	-	898	-	.8004	1.83
Adipic acid	-	385	-	-	-	-	-	-	5.04
Aldol	-	181	-	-	-	-	No	1.11	3.04
Allyl alcohol	-	70	75	3.0	-	713	No	.854	2.00
Allylene	-	Gas	-	1.74	-	-	-	-	.66
Aluminum (powder)	-	-	-	-	-	-	No	-	-
Ammonia (anhydrous)	-	Gas	-	16.0	27.0	1,436	No	-	.597
Amyl acetate-n	-	76	80	1.1	-	714	No	.879	4.49
Amyl acetate-iso	-	92	100	-	-	715	No	.876	4.49
Amyl alcohol-n	Fuse oil	91	120	1.2	-	621	No	.817	3.04
Amyl alcohol-prim. iso ..	Butyl carbinol	109	115	-	-	667	No	.813	3.04
Amyl alcohol-sec. n	-	94	-	-	-	650-725	No	.810	3.04
Amyl alcohol-sec. iso ...	Methyl iso-propyl carbinol	103	-	-	-	-	No	.819	3.04
Amyl chloride	-	-	-	1.4	-	-	No	.878	3.67
Amylene-n	-	-	-	1.6	-	-	No	.666	2.42
Amyl naphthalene	-	-	255	-	-	-	-	.973	6.86
Amyl salicylate	-	270	-	-	-	-	-	1.065	7.17
Aniline	Amino benzene	168	-	-	-	1,418	No	1.022	3.22
Aniline hydrochloride ...	-	-	380	-	-	-	No	1.22	4.46
Anthracene	-	250	385	0.63	-	881 in O_2	No	1.25	1.15
Anthraquinone	-	365	485	-	-	-	No	1.438	7.16
Asphalt (typical)	-	400+	535+	-	-	905	No	.95-1.1	-
Benzaldehyde	Artificial almond oil	148	165	-	-	-	No	1.05	3.66
Benzene	Benzol	12	-	1.4	8	1,076	No	.88	2.77
Benzoic acid	-	250	-	-	-	-	No	1.266	4.21
Benzoyl chloride	-	215	-	-	-	-	-	1.212	4.88
Benzyl acetate	-	216	-	-	-	862	No	1.06	5.17
Benzyl alcohol	Phenyl carbinol	213	220	-	-	817	No	1.04	3.72

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[4] Mellan, Ibert, Industrial Solvents: Reinhold Publishing Corp., New York, N. Y., 2d ed., 1950, pp. 196-205.

Name	Synonyms	Flashpoint, °F.		Explosive limits % by vol. in air		Autoignition temp. °F.	Susceptibility to spontaneous heating	Specific gravity (water = 1.00)	Vapor density (air = 1.00)
		Closed cup	Open cup	Lower	Upper				
Benzyl benzoate	-	298	-	-	-	-	No	1.114	7.31
Benzyl cellosolve	-	-	265	-	-	-	No	1.07	-
Benzyl chloride	-	140	-	1.1	-	-	No	1.103	4.36
Borneol	-	150	-	-	-	-	No	1.01	5.31
Bromobenzene	Phenyl bromide	149	-	-	-	-	No	1.497	5.41
Bronze dust (aluminum free)	-	No hazard		-	-	-	No	-	-
Butadiene-1, 3	Erythrene	Gas	-	2.0	11.5	-	-	.621	1.87
Butane-n	-	-76	Gas	1.6	8.5	806	No	-	2.046
Butyl acetate-n	-	72	90	1.7	15	790	No	.88	4.00
Butyl acetate-iso	-	64	-	-	-	-	No	.871	4.00
Butyl alcohol-n	-	84	110	1.7	-	693	No	.806	2.55
Butyl alcohol-iso	-	82	-	1.68	-	825	No	.805	2.55
Butyl alcohol-ter.	-	52	-	-	-	901	No	.786	2.55
Butyl benzene-sec.	-	126	-	-	-	-	No	.86	4.62
Butyl carbitol	-	172	200	-	-	442	No	.955	5.58
Butyl carbitol acetate ...	-	-	240	-	-	-	No	.987	-
Butyl cellosolve	-	141	165	-	-	472	No	.902	4.07
Butyl chloride-n	I-chloro-butane	-	20	1.85	10.1	860	-	.887	3.20
Butyl decalin	-	500	-	-	-	-	-	-	-
Butyl decalin-ter.	-	640	-	-	-	-	-	-	-
Butylene-n	-	Gas	-	1.7	9.0	-	No	-	0.668
Butylene chloride	-	-	-	2.25	9.25	-	-	.926	3.13
Butylene glycol	-	104	-	-	-	-	No	1.019	3.10
Butyl formate-n	-	64	-	-	-	-	No	.911	3.52
Butyl lactate	-	160	-	-	-	-	No	.968	5.04
Butyl naphthalene	-	680	-	-	-	-	-	-	-
Butyl phthallyl butyl glycollate	-	385	390	-	-	-	No	>1	-
Butyl propionate-n	-	90	110	-	-	800	No	.875	5.00
Butyl ricinoleate	-	230	-	-	-	-	-	.906	-
Butyl stearate-n	-	320	385	-	-	-	-	.855	-
Butyl tetralin-ter	-	680	-	-	-	-	-	-	-
Butyraldehyde	-	20	-	-	-	-	No	.817	2.48
Butyraldoxime	Butanal oxime	136	-	-	-	-	-	.923	3.01
Butyric acid-n	-	170	-	-	-	-	No	.960	3.04
Butyric anhydride-n	-	190	-	-	-	-	-	.978	5.38
Butyrone	-	120	-	-	-	-	No	.815	3.93
Camphor	-	150	200	-	-	871	No	.999	5.24
Camphor oil (light)	-	117	125	-	-	-	No	.88	-
Carbitol	-	201	215	-	-	-	No	.99	4.62
Carbitol acetate	-	225	230	-	-	-	No	1.013	6.07
Carbon disulfide	-	-22	-	1.0	50	257	No	1.256	2.64
Carbon monoxide	-	Gas	-	12.5	74.2	1,204	No	-	.967
Carbonyl sulfide	Carbon oxysulfide	-	-	11.9	28.5	-	-	1.24	2.10
Carnauba wax	-	540	595	-	-	-	-	-	-
Castor oil	-	445	545	-	-	840	Yes	.96	-
Cellosolve	Ethyl cellosolve	104	120	2.6	15.7	460	No	.931	3.10

Name	Synonyms	Flashpoint, °F.		Explosive limits % by vol. in air		Autoignition temp. °F.	Susceptibility to spontaneous heating	Specific gravity (water = 1.00)	Vapor density (air = 1.00)
		Closed cup	Open cup	Lower	Upper				
Cellosolve acetate	-	124	135	1.71	-	715	No	0.975	4.72
Charcoal	Carbon	-		-	-	-	Yes	3.51	-
Chlorobensene	Phenyl chloride	90		-	-	-	No	1.11	3.88
Chloroethyl acetate	-	129		-	-	-	-	1.178	4.21
Chloroform	Trichloromethane	Nonflammable		-	-	-	No	1.489	4.13
Chloronitroethane-1, 1 ...	-	-	133	-	-	-	-	1.258	3.77
Chloronitropropane-1, 1 ..	-	-	144	-	-	-	-	1.209	4.26
Chloronitropropane-2, 2 ..	-	-	135	-	-	-	-	1.193	4.26
Coal tar pitch	-	405	490	-	-	-	-	-	-
Cocoanut oil	-	420	510	-	-	-	Yes	.91	-
Corn oil	-	490	-	-	-	-	Yes	.92	-
Cottonseed oil	-	590	-	-	-	650	Yes	.925	-
Creosote oil	-	165	185	-	-	637	No	>1	-
o-Cresol	o-Methyl phenol	178	-	-	-	-	No	1.05	3.72
p-Cresol	Cresylic acid	187	-	-	-	-	No	1.04	3.72
Crotonaldehyde	-	55	-	2.95	15.5	-	No	.853	2.41
Crotonylene	-	-	-	1.37	-	-	-	-	-
Cyanimide	-	285	405	-	-	-	-	1.073	1.45
Cyclohexane	-	1	-	1.31	8.35	-	No	.779	2.90
Cyclohexanol	Hexalin	154	-	-	-	-	No	.962	3.45
Cyclohexanone	-	147	-	-	-	-	No	.947	3.38
Cyclohexanone delta	-	93	-	-	-	-	No	-	3.31
Cyclohexyl acetate	Hexalin acetate	136	-	-	-	-	No	-	4.90
Cyclohexylamine	-	-	90	-	-	-	-	.865	3.42
Cyclopropane	Trimethylene	Gas	-	2.41	10.3	-	No	-	1.45
p-Cymene	-	117	145	-	-	921	No	.86	4.62
Decahydronaphthalene	Decalin	136	-	-	-	504	No	.895	4.76
Decane-n	-	115	-	0.67	2.6	>500	No	.730	4.90
Denatured alcohol—95% ...	-	60	-	-	-	-	No	.82	1.60
Diacetone alcohol (comm'l.)	-	48	55	-	-	-	No	.931	4.00
Diamy phenoxy ethanol	-	-	300	-	-	-	-	.959	9.6
Diamyl phthalate	-	245	340	-	-	-	-	-	-
Dianisidine	-	403	-	-	-	-	-	-	-
Dibensyl ether	-	275	-	-	-	-	No	1.036	6.82
Dibutyl ether-n	-	77	-	-	-	-	No	.769	4.48
Dibutyl oxalate-n	-	220	-	-	-	-	No	1.01	-
Dibutyl phthalate-n	-	315	335	-	-	-	No	1.045	9.58
Dibutyl phthalate-iso	-	322	-	-	-	-	No	-	9.58
Dibutyl sebacate	-	-	353	-	-	-	-	.936	-
Dibutyl tartrate-n	-	195	230	-	-	-	No	1.098	9.03
o-Dichlorobenzene	-	151	165	-	-	-	No	1.325	5.07
p-Dichlorobenzene	-	150	165	-	-	-	No	1.458	5.07
Dichlorodifluoromethane ..	Freon, F-12	Nonflammable		-	-	-	No	-	-
Dichloro ethylene 1, 1 ...	Dichloro ethene 1, 1	57	-	5.6	13	856	No	1.250	3.35
Dichloro ethylene 1, 2 ...	Acetylene dichloride	43	-	9.7	12.8	-	No	1.282	3.35
Dichloroethyl ether-sym. .	-	131	185	-	-	696	No	1.22	4.93
Dichloroisopropyl ether ..	-	-	185	-	-	-	No	1.113	-
1, 1 Dichlero 1 Nitro ethane	-	-	168	-	-	-	-	1.405	4.97
1, 1 Dichloro, 1 Nitro propane	-	-	151	-	-	-	-	1.314	5.45
Dichlorotetrafluorethane .	F-114	Nonflammable		-	-	-	No	-	-

Name	Synonyms	Flashpoint, °F.		Explosive limits % by vol. in air		Autoignition temp. °F.	Susceptibility to spontaneous heating	Specific gravity (water = 1.00)	Vapor density (air = 1.00)
		Closed cup	Open cup	Lower	Upper				
Dieyelohexylamine	-	-	>210	-	-	1, -	-	0.910	6.27
Diethanolamine	-	-	280	-	-	1,224	No	1.097	3.65
Diethylamine	-	< 0	< 0	-	-	-	-	.710	2.53
Diethylaminoethanol	-	-	140	-	-	-	No	.885	-
Diethyl carbitol	-	-	180	-	-	-	No	.908	-
Diethyl carbonate	-	77	-	-	-	-	No	.977	4.07
Diethyl cellosolve	-	-	95	-	-	-	No	.842	-
Diethyl diphenyl urea	-	302	-	-	-	-	-	-	-
Diethylene glycol	-	255	290	-	-	444	No	1.119	3.66
Diethylene oxide	Dioxan	65	-	1.97	22.2	-	-	1.035	3.03
Diethylene triamine	-	-	215	-	-	-	-	.954	3.48
Diethyl ether	Ether	-20	-	1.7	48.0	366	No	.71	2.55
Diethyl glycophthalate ...	-	343	-	-	-	-	-	-	-
p-Diethyl phthalate	-	243	305	-	-	-	-	1.110	7.66
Diethyl selenide	-	-	-	2.5	-	-	No	1.23	4.73
Diethyl sulfate	-	220	-	-	-	-	No	1.184	5.31
Diglyeol chlorohydrin	-	-	225	-	-	-	No	1.172	-
Dimethoxy Tetraglyeol	-	-	285	-	-	-	No	1.013	-
Dimethyl aniline	-	145	170	-	-	700	No	.956	4.17
p-Dimethyl cyclohexane ...	Hexahydroxylol	52	-	-	-	-	No	.77	3.86
Dimethyl ether	Methyl ether	-42	-	-	-	-	No	-	1.617
Dimethyl glycophthalate ..	-	369	-	-	-	-	No	-	9.72
o-Dimethyl phthalate	-	295	325	-	-	-	No	1.189	6.69
Dimethyl sulfate	Methyl sulfate	182	240	-	-	-	No	1.332	4.35
Dinitro aniline-2, 4	-	435	510	-	-	-	-	1.615	6.31
Dinitro benzene	-	302	-	-	-	-	-	1.59	5.79
Dinitro chlorobensene	-	382	405	-	-	-	-	1.68	6.98
Dinitro toluene-2, 4	-	-	-	-	-	-	No	1.52	6.27
Diphenyl	-	235	255	-	-	-	No	1.041	5.31
Diphenylamine	-	307	-	-	-	-	No	1.16	5.82
Diphenyl methane	Ditane	266	-	-	-	-	No	1.006	5.79
Diphenyl oxide	Diphenyl ether	239	-	-	-	-	No	1.073	5.86
Dipropylene glycol	-	-	280	-	-	-	No	1.040	-
Divinyl ether	Vinyl ether	<-22		1.7	27.0	680	No	.774	-
Dodecane	Dihexyl	165	-	0.6	-	-	No	0.750	5.86
Ester gum	-	375	555	-	-	-	No	-	-
Ethane	-	Gas	-	3.12	15.0	950	No	-	1.049
Ethanolamine	-	-	200	-	-	-	No	1.02	2.10
Ethyl acetanilide	-	126	-	-	-	-	-	.942	4.72
Ethyl acetate	Acetic ether	24	30	2.18	11.5	907	No	.899	3.04
Ethyl acetoacetate	Acetoacetic ester	184	-	-	-	-	No	1.03	4.48
Ethyl alcohol	Ethanol	55	-	3.28	19	799	No	.79	1.59
Ethyl bensene	Phenyl ethane	59	75	-	-	-	No	.868	3.66
Ethyl bromide	Bromoethane	-	-	6.75	11.25	952	No	1.430	3.76
Ethyl butyl carbonate	-	122	-	-	-	-	No	-	5.03
Ethyl butyrate	-	78	85	-	-	-	No	.879	4.00
Ethyl chloride	Chloroethane	-58	-45	3.6	14.8	-	No	.910	2.22
Ethylene	-	Gas	-	3.02	34	1,009	No	-	.975
Ethylene chlorohydrin	-	-	140	-	-	-	No	1.213	2.78
Ethylene diamine	-	93	110	-	-	-	No	.890	2.07
Ethylene dichloride	Dichloro ethane-1, 2	56	65	6.2	15.9	775	No	1.258	3.42
Ethylene glycol	Glycol	232	240	-	-	775	No	1.113	2.14
Ethylene oxide	-	-	-	3	80	804	No	.887	1.52
Ethyl formate	-	-4	10	3.5	16.5	-	No	.922	2.55

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		Closed cup	Open cup	Lower	Upper				
Ethyl glycol acetate	-	117	-	-	-	-	No	-	4.55
Ethyl lactate	-	115	-	-	-	-	No	1.03	4.41
Ethyl mercaptan	Ethyl sulfhydrate	-	-	2.8	18.2	570	-	0.839	2.11
Ethyl nitrate	Nitric ether	50	50	3.8	-	-	No	1.105	3.14
Ethyl nitrate	Nitrous ether	-31	-30	3.01	>50	-	No	.900	2.59
Ethyl oxalate	-	-	-	-	-	-	No	1.080	5.04
Ethyl phthallyl ethyl glycollate	-	365	385	-	-	-	-	>1	-
Ethyl propionate	-	54	-	-	-	-	No	.891	3.52
Ethyl silicate	-	-	125	-	-	-	-	.936	7.22
Ethyl p-toluene sulfonamide	-	260	380	-	-	-	-	-	-
Ethyl p-toluene sulfonate	-	316	-	-	-	-	-	-	-
Formaldehyde, (gas)	Methanal	-	-	-	-	806	No	-	1.03
(soln. of gas in water)	-	130	200	-	-	-	No	-	-
Formic acid	-	156	-	-	-	-	-	1.218	1.59
Fuel oil No. 1	Range oil	100-165	-	-	-	490	No	<1	-
Fuel oil No. 2	-	110-190	-	-	-	494	No	<1	-
Fuel oil No. 3	-	125-200	-	-	-	498	No	<1	-
Fuel oil No. 4	-	150+	250	-	-	505	No	<1	-
Fuel oil No. 5	-	150+	-	-	-	-	No	<1	-
Fuel oil No. 6	-	150+	320	-	-	765	No	<1	-
Furfural	-	140	155	2.1	-	739	No	1.159	3.31
Furfural alcohol	Furfuryl carbinol	-	-	-	-	915	-	1.129	3.37
Gas, blast furnace	-	-	-	35	74	-	No	-	-
Gas, coal gas	-	-	-	5.3	31	1,200	No	-	-
Gas, illuminating	-	-	-	5.3	31	1,094	No	-	-
Gas, natural	-	-	-	4.8	13.5	-	No	-	-
Gas, oil gas	-	-	-	6.0	13.5	637	No	-	-
Gas, producer	-	-	-	20.7	73.7	-	No	-	-
Gas, water	-	-	-	9.0	55.0	-	No	-	-
Gas oil	-	150+	-	-	-	640	No	<1	-
Gasoline	-	-50	-	1.3	6	495	No	.75	3-4
Glycerine	Glycerol	320	350	-	-	739	No	1.26	3.17
Glyceryl triacetate	Triacetin	280	295	-	-	-	No	1.161	7.52
Glycol diacetate	Ethylene acetate	-	220	-	-	-	No	1.100	4.53
Heptane-n	-	25	-	1	6	452	No	.683	3.45
Hextane-n	-	7	-	1.25	6.90	477	No	.661	2.97
Hexyl acetate	Ethyl butyl acetate	135	-	-	-	-	No	.83	4.97
Do.	Methyl amyl acetate	113	-	-	-	-	No	.855	4.97
Hexyl alcohol-n	Hexanol-n	145	-	-	-	-	No	.82	3.52
Hexyl alcohol	Ethyl butyl alcohol	137	-	-	-	-	No	.818	3.52
Do.	Methyl amyl alcohol	114	-	-	-	-	No	.804	3.52
Hydrocyanic acid	-	0	-	5.6	40	1,000	No	.697	.9
Hydrogen	-	Gas	-	4.1	74.2	1,076	No	-	.069
Hydrogen sulfide	-	Gas	-	4.3	45.5	-	No	-	1.189
Hydroquinone	-	329	-	-	-	-	-	1.332	3.81
Isobutyraldehyde	-	-40	-	-	-	490	-	.813	-
Kerosine	No. 1 fuel oil	100-165	-	-	-	490	No	<1	-
Lanolin	Wool grease	460	560	-	-	833	Yes	<1	-
Lard oil (commercial)	-	395	-	-	-	833	Yes	<1	-
Lead tetramethyl	-	-	-	1.8	-	-	-	1.995	9.20
Linseed oil	-	435	535	-	-	820	Yes	.93	-

Name	Synonyms	Flashpoint, °F.		Explosive limits % by vol. in air		Autoignition temp. °F.	Susceptibility to spontaneous heating	Specific gravity (water = 1.00)	Vapor density (air = 1.00)
		Closed cup	Open cup	Lower	Upper				
Lubricating oil, cylinder	-	-	535	-	-	783	No	<1	-
Lubricating oil, light machine	-	318	370	-	-	-	No	<1	-
Lubricating oil, motor ...	-	-	450	-	-	-	No	<1	-
Lubricating oil, spindle .	-	169	200	-	-	-	No	<1	-
Lubricating oil, turbine .	-	-	400	-	-	700	No	<1	-
Magnesium (powder or chips)	-	-	-	-	-	-	No	-	-
Manganese (powder)	-	-	-	-	-	-	No	-	-
Menhaden oil	-	435	-	-	-	828	Yes	0.927	-
Mesityl oxide	-	87	-	-	-	-	-	.858	3.40
Metaldehyde	m-Acetaldehyde	97	-	-	-	-	No	-	6.06
Methane	Marsh gas	Gas	-	5.3	13.9	999	No	-	.554
Methoxy ethyl phthalate ..	Methox	275	370	-	-	-	No	-	-
Methyl acetate	-	15	20	4.1	13.9	935	No	.925	2.56
Methyl acetoacetate	-	180	-	-	-	-	No	1.077	4.00
Methyl alcohol	Methanol	54	60	6.0	36.5	878	No	.792	1.11
Methyl amine	-	0	10	-	-	-	No	.699	-
Methyl bromide	Bromomethane	Practically nonflammable		13.5	14.5	-	No	1.732	3.27
Methyl n-butyl ketone	Hexanone	-	95	1.22	8.0	-	No	.830	3.45
Methyl iso-butyl ketone ..	do.	73	-	-	-	-	No	.803	3.45
Methyl butyrate		57	-	-	-	-	No	.898	3.52
Methyl carbitol	-	-	200	-	-	-	No	1.035	4.14
Methyl cellosolve	-	107	115	-	-	551	No	.966	2.62
Methyl cellosolve acetate.	-	132	140	8.2	-	-	No	1.005	4.07
Methyl chloride	Chloromethane	Gas	-	1.15	19.7	-	No	.92	1.78
Methyl cyclohexane	-	25	-		-	-	No	.770	3.38
Methyl cyclohexanol	Methyl hexalin	154	-	-	-	-	No	.933	3.93
Methyl cyclohexanone	-	118	-	-	-	-	No	.925	4.86
Methyl cyclohexyl acetate.	-	147	-	-	-	-	No	-	5.37
Methylene chloride	Dichloromethane	Practically nonflammable		-	-	1,224	No	1.336	2.93
Methyl ethyl ether	-	-35	-	2	10.1	374	No	.697	2.07
Methyl ethyl ketone	-	30	-	1.81	11.5	-	No	.805	2.41
Methyl formate	-	-2	-	5.0	22.7	840	No	.975	2.07
Methyl glycol	-	97	-	-	-	-	No	-	2.62
Methyl glycol acetate	-	111	-	-	-	-	No	-	4.07
Methyl phthally ethyl glycollate	-	375	380	-	-	-	No	>1	-
Methyl propionate	-	28	-	-	-	-	No	.915	3.03
Methyl n-propyl ketone ...	Pentanone	-	60	1.55	8.15	-	No	.812	2.96
Methyl salicylate	Oil of wintergreen	214	225	-	-	850	No	1.182	5.24
Mineral seal oil (typical)	-	170	255	-	-	-	No	-	-
Monocresy diphenyl phosphate	-	450	450	-	-	-	No	>1	-
Monofluorotrichloromethane	F-11	Nonflammable		-	-	-	No	-	-
Mustard oil	-	566	-	-	-	-	Yes	1.02	-
Naphtha, coal tar	Hi-flash naphtha	100-110	-	-	-	900-950	No	<1	-
Naphtha, safety solvent ..	Stoddard solvent, mineral spirits	100-110	-	1.1	6.0	450-500	No	<1	-
Naphtha, V. M. & P.	Benzine	20-45	-	1.2	6.0	450-500	No	<1	-

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		Closed cup	Open cup	Lower	Upper				
Naphthalene	-	174	190	0.9	-	1,053	No	1.145	4.42
Naphthol, beta	-	307	340	-	-	-	No	1.22	4.97
Naphthylamine-alpha	-	315	-	-	-	-	No	1.171	4.93
Neatsfoot oil	-	470	-	-	-	828	Yes	.92	-
Nicotine	-	-	-	.75	4.0	471	-	1.009	5.61
p-Nitroaniline	Paranitraniline	390	390	-	-	-	-	1.437	-
Nitrobenzene	-	190	-	-	-	924	-	1.2	4.25
p-Nitrochlorobenzene	-	261	-	-	-	-	-	1.52	5.43
Nitroethane	-	82	106	-	-	-	-	1.052	2.58
Nitroglycerin	Glyceryl trinitrate	Explodes	-	-	-	518	No	1.601	7.84
Nitromethane	-	-	-	-	-	-	-	1.139	2.11
Nitronaphthalene-alpha	-	327	-	-	-	-	-	1.331	5.96
1-Nitropropane	-	-	-	-	-	-	-	1.003	3.06
2-Nitropropane	-	-	-	-	-	-	-	.992	3.06
p-Nitrotoluene	-	223	-	-	-	-	-	1.286	4.72
m-Nitro p-toluidine	-	315	345	-	-	-	-	1.312	5.24
Nonane-n	-	88	-	.74	2.9	-	No	.718	4.41
Octane-n	-	56	-	.84	3.2	450	No	.706	3.86
Octyl acetate-n	-	180	-	-	-	-	No	.885	5.93
Octyl alcohol-n	-	178	-	-	-	-	No	.827	4.48
Octyl aldehyde	-	125	-	-	-	-	No	.821	4.41
Oleic acid	Red oil	372	-	-	-	685	Yes	.891	-
Oleo oil	-	-	-	-	-	-	Yes	.915	-
Olive oil	-	437	-	-	-	826	Yes	.910	-
Ozokerite	-	236	315	-	-	-	No	.95	-
Palm oil	-	421	-	-	-	650	Yes	.92	-
Paraffin wax	-	390	430	-	-	473	No	.9	-
Paraformaldehyde	-	158	200	-	-	-	No	-	-
Peanut oil	-	540	-	-	-	833	Yes	.92	-
Pentane-n	-	<-40	-	1.4	8.0	588	No	.631	2.48
Perilla oil	-	522	-	-	-	-	Yes	.93	-
Petroleum, crude	-	20-90	-	-	-	-	No	<1	-
Petroleum ether	-	-50	-	1.4	5.9	475	No	.64	2.50
Phenanthrene	-	-	-	-	-	-	No	1.063	6.14
Phenol	Carbolic acid	175	185	-	-	1,319	No	1.07	3.24
Phenyl cellosolve	-	-	250	-	-	-	No	1.109	-
p-Phenylene diamine	-	312	310	-	-	-	No	-	3.72
Phenyl ethyl alcohol	-	216	-	-	-	-	No	1.024	4.21
Phosphorus (red)	-	-	-	-	-	500	No	2.30	-
Phosphorous (yellow)	-	-	-	-	-	86	No	1.82	-
Phosphorous sesquisulfide	-	-	-	-	-	212	No	2.03	-
Phthalic anhydride	-	305	330	-	-	-	No	1.527	5.10
Picric acid	Trinitrophenol	Explodes	-	-	-	<572	No	1.763	7.90
Pine oil	-	172	175	-	-	-	Yes	.86	-
Pine pitch	-	285	-	-	-	-	Yes	-	-
Pine resin	Colophony	370	430	-	-	-	Yes	1.08	-
Pine tar	-	130	255	-	-	671	Yes	-	-
Pine tar oil	-	144	-	-	-	-	Yes	.862	-
Potassium	-	-	-	-	-	-	No	.862	-
Potassium xanthate	-	205	-	-	9.5	-	No	1.558	-

Name	Synonyms	Flashpoint, °F.		Explosive limits % by vol. in air		Autoignition temp. °F.	Susceptibility to spontaneous heating	Specific gravity (water = 1.00)	Vapor density (air = 1.00)
		Closed cup	Open cup	Lower	Upper				
Propane	-	Gas	-	2.37	9.5	871	No	-	1.56
Propyl acetate-n	-	58	-	2.0	-	-	No	0.886	3.52
Propyl acetate-iso	-	43	45	2.0	-	860	No	.877	3.52
Propyl alcohol-n	-	59	85	2.5	-	812	No	.804	2.07
Propyl alcohol-iso	-	53	60	2.5	-	852	No	.789	2.07
Propyl alcohol-sec.	Dimethyl carbinol	67	-	-	-	-	No	.79	2.07
Propyl benzene-n	-	86	-	-	-	-	No	.862	4.14
Propyl benzene-iso	Cumene	102	-	-	-	-	No	.864	4.14
Propyl chloride-n	1-chloropropane	-	-	2.6	10.5	-	-	.890	2.71
Propylene	-	Gas	-	2.0	11.1	-	No	-	1.49
Propylene chlorohydrin ...	-	125	125	-	-	-	No	1.113	3.26
Propylene dichloride	Dichloropropane-1, 2	59	65	3.4	14.5	1,035	No	1.15	3.89
Propylene glycol	-	210	225	-	-	-	No	1.040	2.52
Propylene oxide	-	20	-	-	-	-	No	.859	2.00
Propyl ether-iso	-	-18	-15	-	-	830	No	.73	3.52
Propyl formate-n	-	27	-	-	-	-	No	.909	3.03
Propyl formate-iso	-	22	-	-	-	-	No	.873	3.03
Pyridine	-	68	-	1.8	12.4	1,065	No	.982	2.73
Pyrocatechol	O-Dihydroxy benzene	261	-	-	-	-	No	1.344	3.79
Quenching oil	-	365	405	-	-	-	No	.9	-
Rape seed oil	-	325	550	-	-	836	Yes	.915	-
Resorcinol	m-Dihydroxy benzene	261	-	-	-	-	No	1.272	3.79
Rosin oil	-	266	-	-	-	648	Yes	.98-1.1	-
Sodium	-	-	-	-	-	-	No	.97	-
Sodium formate	-	-	-	-	-	-	No	1.919	-
Soya bean oil	-	540	-	-	-	833	Yes	.925	-
Stearic acid	-	385	425	-	-	743	Yes	.847	9.80
Styrene	-	90	-	1.1	6.1	914	-	.907	3.60
Sulfur	-	405	440	-	-	450	No	2.046	-
Sulfur chloride	-	245	None	-	-	453	No	1.687	3.31
Tallow	-	509	-	-	-	-	Yes	.895	-
Tallow oil	-	492	-	-	-	-	Yes	.914	-
Tannic acid	-	-	390	-	-	-	No	-	-
Tartaric acid	Racemic acid	-	410	-	-	-	No	1.667	-
Terphenyl-o	-	-	325	-	-	-	-	1.14	7.95
Terphenyl-m	-	-	375	-	-	-	-	1.164	7.95
Terphenyl-p	-	-	405	-	-	-	-	1.236	7.95
Tetrachloroethylene	Perchlorethylene	Nonflammable		-	-	-	No	1.623	5.72
Tetradecane	-	212	-	0.5	-	-	No	.765	6.83
Tetraethylene glycol	-	-	345	-	-	-	No	1.126	-
Tetrahydronaphthalene	Tetralin	171	180	-	-	-	No	.973	4.55
Tin tetramethyl	-	-	-	1.9	-	-	No	1.314	-
Toluene	Toluol	40	45	1.27	7.0	1,026	No	.866	3.14
o-Toluidine	2-Methyl aniline	185	-	-	-	900	No	.999	3.90
p-Toluidine	4-Methyl aniline	188	205	-	-	900	No	.973	3.90
o-Tolyl p-toluene sulfonate	-	363	-	-	-	-	-	-	-
Transil oil	Transformer oil	-	295	-	-	-	No	.9	-
Tributyl citrate	-	315	365	-	-	695	-	-	-

Name	Synonyms	Flashpoint, °F. Closed cup	Open cup	Explosive limits % by vol. in air Lower	Upper	Autoignition temp. °F.	Susceptibility to spontaneous heating	Specific gravity (water = 1.00)	Vapor density (air = 1.00)
Tributyl phosphate	-	-	295	-	-	-	No	0.973	8.86
Trichloroethylene	-	Nonflammable		-	-	-	No	1.47	4.53
o-Tricresyl phosphate	-	460	504	-	-	-	No	-	-
Triethanolamine	-	355	365	-	-	-	No	1.13	5.14
Triethylene glycol	Dicaproate	350	385	-	-	-	No	1.125	5.17
Triethylene tetramine	-	-	260	-	-	-	No	0.982	-
Triglycol dichloride	-	-	250	-	-	-	No	1.197	-
Triisopropanolamine	-	-	305	-	-	-	No	1.020	-
Triphenyl phosphate	-	428	-	-	-	-	No	-	-
Tung oil	China wood oil	552	-	-	-	855	Yes	.94	-
Turkey red oil	-	476	--	-	-	833	No	-	-
Turpentine	-	95	-	0.8	-	488	Yes	<1	-
Vinyl acetate	-	18	30	-	-	800	No	-	-
Vinyl chloride	-	-	-	4	22	-	No	.97	2.15
Vinyl ether	Divinyl ether	< -22	-	1.85	36.5	680	-	.774	2.41
Whale oil	Sperm oil	446	-	-	-	-	Yes	.925	-
o-Xylene	o-Xylol	63	75	1.0	-	924	No	.88	3.66
o-Xylidine	o-Dimethyl aniline	206	-	-	-	-	No	.99	4.17
Zinc (dust or powder)	-	-	-	-	-	-	No	-	-
Zirconium (powder)	-	-	-	-	-	550	No	-	-

ICC Shipping Labels

Red - Flammable liquids with flash points at or below 80° F. and flammable compressed gases.

Yellow - Flammable solids (except explosives) and oxidizing materials (chlorates, permanganates, peroxides, nitrates).

White - Corrosive liquids (mineral acids).

Green - Nonflammable compressed gases.

Labels are required only for interstate shipments or for intrastate shipments by common carrier engaged in interstate or foreign commerce. Absence of a label does not necessarily mean that the material is nonhazardous.

Maximum allowable concentrations for solvents

Threshold Limit Values

Adopted at the Seventeenth Annual Meeting of the American Conference
of Governmental Industrial Hygienists, Buffalo, N.Y., Apr. 24-28, 1955

Established Values

Gases and vapors	Parts per million
Acetaldehyde	200
Acetic acid	10
Acetic anhydride	5
Acetone	1,000
Acrolein	.5
Acrylonitrile	20
Ammonia	100
Amyl acetate	200
Amyl alcohol (isoamyl alcohol)	100
Aniline	5
Arsine	.05
Benzene (benzol)	35
Bromine	1
Butadiene (1, 3-butadiene)	1,000
Butanone (methyl ethyl ketone)	250
Butyl acetate (n-butyl acetate)	200
Butyl alcohol (n-butanol)	100
Butyl cellosolve (2-butoxyethanol)	200
Carbon dioxide	5,000
Carbon disulfide	20
Carbon monoxide	100
Carbon tetrachloride	25
Cellosolve (2-ethoxyethanol)	200
Cellosolve acetate (hydroxyethyl acetate)	100
Chlorine	1
Chlorobenzene (monochlorobenzene)	75
Chloroform (trichloromethane)	100
1-Chloro-1-nitropropane	20
Chloroprene (2-chlorobutadiene)	25
Cresol (all isomers)	5
Cyclohexane	400
Cyclohexanol	100
Cyclohexanone	100
Cyclohexene	400
Cyclopropane	400
o-Dichlorobenzene	50
Dichlorodifluoromethane	1,000
1, 1-Dichloroethane	100
1, 2-Dichloroethylene	200
Dichloroethyl ether	15
Dichloromonofluoromethane	1,000
1, 1-Dichloro-1-nitroethane	10
Dichlorotetrafluoroethane	1,000
Diethylamine	25
Dimethylaniline (N-dimethylaniline)	5
Dimethylsulfate	1
Dioxane (diethylene dioxide)	100
Ethyl acetate	400
Ethyl alcohol (ethanol)	1,000
Ethylamine	25
Ethyl benzene	200
Ethyl bromide	200
Ethyl chloride	1,000
Ethyl ether	400
Ethyl formate	100
Ethyl silicate	100
Ethylene chlorohydrin	5
Ethylene dibromide (1, 2-dibromoethane)	25
Ethylene dichloride (1, 2-dichloroethane)	100
Ethylene oxide	100
Fluorine	.1
Fluorotrichloromethane	1,000
Formaldehyde	5
Gasoline	500
Heptane (n-heptane)	500
Hexane (n-hexane)	500
Hexanone (methyl butyl ketone)	100
Hexone (methyl isobutyl ketone)	100
Hydrogen chloride	5
Hydrogen cyanide	10
Hydrogen fluoride	3
Hydrogen selenide	.05
Hydrogen sulfide	20
Iodine	1
Isophorone	25
Mesityl oxide	50
Methyl acetate	200
Methyl alcohol (methanol)	200
Methyl bromide	20
Methyl cellosolve (methoxyethanol)	25
Methyl cellosolve acetate (ethylene glycol monomethyl ether acetate)	25
Methyl chloride	100
Methylal (dimethoxymethane)	1,000
Methyl chloroform (1, 1, 1-trichloroethane)	500
Methylcyclohexane	500
Methylcyclohexanol	100
Methylcyclohexanone	100
Methyl formate	100
Methylene chloride (dichloromethane)	500
Naphtha (coal tar)	200
Naphtha (petroleum)	500
Nickel carbonyl	.001
Nitrobenzene	1
Nitroethane	100
Nitrogen dioxide	5
Nitroglycerin	.5
Nitromethane	100
2-Nitropropane	50
Nitrotoluene	5
Octane	500
Ozone	.1
Pentane	1,000
Pentanone (methyl propyl ketone)	200
Perchlorethylene (tetrachloroethylene)	200
Phenol	5
Phosgene (carbonyl chloride)	1
Phosphine	.05
Phosphorus trichloride	.5
Propyl acetate	200
Propyl alcohol (isopropyl alcohol)	400
Propyl ether (isopropyl ether)	500
Propylene dichloride (1, 2-dichloropropane)	75
Stibine	.1
Stoddard solvent	500
Styrene monomer (phenyl ethylene)	200
Sulfur monochloride	1
Sulfur dioxide	10
1, 1, 2, 2-Tetrachloroethane	5
Toluene	200
o-Toluidine	5
Trichloroethylene	200
Turpentine	100
Vinyl chloride (chloroethene)	500
Xylene	200

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